✓ §23.305 ALL AMNDTS

Memorandum

U.S. Department
of Transportation

**Federal Aviation
Administration**

Subject: **INFORMATION**: Demonstration of Compliance with FAR §23.305; ANE-171 Memo of 5/23/97

Date: June 18, 1997

From: Manager, Regulations and Policy Branch, ACE-111

Reply to Attn. of: David Showers (816)426-6941

To: Manager, Airframe and Propulsion Branch, ANE-171

Our office has reviewed the subject memo with the following response. Where appropriate, we discuss your comments in these two distinct contexts:

a. During evaluation whether a tested article may be acceptable for subsequent operational use or flight tests, and

b. During demonstration that a design complies with the FARs.

Paragraph 1:

"The purpose of this memo is to request a minimal acceptable means of compliance for the practice of applying ultimate proof test loads to flight structures."

Compliance with FAR §23.305 must be demonstrated. This paragraph requires as a minimum:

a. Structure must support limit loads without detrimental, permanent deformation. Also, for loads up to limit load, deformations may not interfere with safe operation; and

b. Structure must support ultimate loads without failure for at least three seconds, except local failures or structural instabilities are acceptable only if the structure can maintain ultimate load for at least three seconds. When proof of strength is shown by dynamic tests simulating actual load conditions, the three second rule does not apply.

Compliance must be demonstrated as specified in FAR §23.307. For composite materials, guidance for "Proof of Structure - Static" is contained in AC 20-107A, paragraph 6.

"This practice is sometimes used by applicants during STC modifications. Motivation for the practice comes from the applicant's desire to fulfill the FAR requirements without the use of a non-flight test article."

This motivation is understood but does not alleviate the need to demonstrate compliance with FAR §23.305.

Paragraph 2:

"Justification of this practice requires that the load-deflection curve remains linear up to the ultimate test load."

a. This is one of the requirements that must be considered before tested structure can be approved for subsequent operational use or flight test. Linear load-deflection curves up to the maximum applied test load are one indication that detrimental, permanent deformation (FAR §23.305(a)) has not occurred. This and other requirements that must be considered are described in more detail in paragraph a) below.

b. For the context of demonstrating design compliance with the FARs, Part 23 Strength and Deformation requirements do not require a linear load-deflection curve beyond limit load. Demonstrating a linear load-deflection curve up to ultimate load far exceeds the minimum requirements of FAR §23.305(a).

"If this occurs and the yield strength of all materials involved are less than two thirds of their ultimate value, you will meet the intent of FARs §XX.303, XX.305, and XX.307 which requires subjecting the structure to ultimate flight loads and at the same time assure a factor of safety of at least 1.5."

a. This is not true. When evaluating a tested structure for subsequent operational use or flight test, it would not be necessary for the yield strength to be less than two thirds of the ultimate value. The main concern in such an evaluation is whether the actual applied test load caused detrimental, permanent deformation or caused any other deviations to type design. Any post-test deviations to the type design must be dispositioned prior to the tested structure being used for flight. A static test structure that has yielded is not a candidate for subsequent operational use or flight tests.

There are many factors that should be considered on a case-by-case basis when evaluating tested structure for subsequent operational use or flight test:

1. <u>The criticality of the tested structure:</u> The concern for primary load carrying members, such as a PSE, is greater than that for a secondary structure. A bracket used to support an avionics installation is less of a concern than a wing spar or fuselage frame.

2. The magnitude of the loads applied to the tested structure: Floor structure tested to loads simulating ultimate design conditions for the floor might not be deemed acceptable for subsequent use. The same floor structure, acted upon by ultimate test loads substantiating support brackets for a small avionics installation, might be deemed acceptable.

3. The effect the test load may have on the subsequent fatigue life of the part: It should be determined that static testing will not degrade the fatigue life of tested structure. In general, for metallic parts, accumulated fatigue damage resulting from a single static overload should be offset by the beneficial effects of crack retardation. Special care should be excersized however, for static test overloads on cold-worked or pre-loaded metallic parts. Compressive test loads may negate the fatigue benefits of residual compression caused by cold-working. Tensile test loads may yield pre-loaded bolts, reducing their pre-load with no discernible change in overall deflections. These and other non-elastic effects should be considered on a case-by-case basis.

b. When demonstrating design compliance with the FARs, a linear load-deflection curve up to ultimate load (provided ultimate load is withstood for 3 seconds) demonstrates compliance with two requirements of FAR §23.305 simultaneously:

1. No detrimental, permanent deformation at limit load, and

2. No failure at ultimate loads.

It is not necessary for yield strength to be less than two thirds of ultimate.

Paragraph 3:

"In many cases, due to limited instrumentation, accurate load-deflection data is not recorded. Without an elaborate set of strain gages installed on both the STC modification and the primary aircraft, it is difficult to determine where yielding has occurred if the load-deflection curve becomes non-linear. Replacing parts which are visibly distorted may not assure that all remaining parts have not yielded."

This poses a difficult problem. The best combination of test, analysis, examination, or detailed inspection must be used to ensure that structure returned to service meets type design and has not sustained detrimental, permanent deformation.

Paragraph 4:

"This practice with composite materials is a particular concern to the New York ACO. Since composite materials exhibit load-deflection linearity almost up to material ultimate, a linear load-deflection curve to ultimate flight loads does not assure a factor of safety of 1.5 as required by FAR §XX.303."

a. When evaluating a tested article for subsequent operational use or flight test, the criteria described above under Paragraph 2 (a) should be applied.

b. When demonstrating design compliance with the FARs, withstanding ultimate test loads for 3 seconds demonstrates compliance with FAR §23.305(b). This is true for composite materials provided that defects, damage, environmental effects, and manufacturing variability have been properly accounted for as described below. The fact that load-deflection data is linear up to ultimate load demonstrates that the "no detrimental, permanent deflection for limit loads" requirements of §FAR 23.305(a) are exceeded by 50%.

The fact that composite materials exhibit load-deflection linearity almost up to material ultimate has no effect on the factor of safety. Consider the sequence of determining limit loads, factor of safety, and ultimate loads:

1. Limit loads are the "maximum loads to be expected in service" (FAR §23.301(a)).

2, "Unless otherwise provided, a factor of safety of 1.5 must be used (FAR §23.303)."

3. The ultimate load requirements of FAR §23.305(b) are the limit loads multiplied by 1.5.

For composite materials we must account for defects (i.e. intrinsic, manufacturing), damage (i.e. fatigue, corrosion, damage from discrete sources such as impact), environmental effects, and manufacturing variability in accordance with the applicable regulatory and guidance material. If "knock-down" factors are used to account for these effects, required test loads may exceed ultimate load requirements by the appropriate factor.

Paragraph 5:

"Please advise the NYACO what is a minimal acceptable means of compliance for the practice of applying ultimate proof test loads to flight structures."

We provide the above response to your memo.

Thank you for raising these important issues. We hope we can be of further service to you in the future. If you have any questions, please contact David Showers at (816)426-6941.

/s/
Marvin Nuss

cc:
AIR-100 (J. Soderquist)

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